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REVIEW OF INVESTIGATIONS ON PHYSIOLOGICAL DISEASES OF RICE-I

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Sources of information

Information on this subject was collected from the following countries: Burma, Cambodia, Ceylon, China (Taiwan), Indonesia, Japan, Korea, Laos, Malaya, Pakistan, Philippines, Thailand, U.S.A. and Vietnam. In Laos, Philippines and Vietnam, no pertinent work has been done.

It seems that the dominant type of the physiological disease of rice is the one which occurs under stagnant water at the tillering stage of the rice plant. The following diseases reported from the different countries may be classed under this group.

Amyitpo	Burma
Bronzing (Browning)	Ceylon
Mentek	Indonesia
Akagare	Japan
Stifle	Korea
Penyakit Merah	Malaya
Pansuk	Pakistan

The symptoms, soil and climatic conditions, time of appearance of the disease, relation to fertilizers, area affected, varietal reactions, possible causes, and remedial measures of the above-mentioned diseases will be presented in the second part of this review in the next issue of IRC Newsletter.

This type of physiological disease is also reported from Thailand. Its characteristic feature is the withering of the leaves of the whole hill just at the time when the transplanted seedlings start tillering, i.e. about 3-5 weeks or more after transplanting. Affected plants that were pulled out and examined showed that the colour of the roots and soil clinging to the roots is usually black or dark brown. In almost all cases, the soil where affected plants are found is rich in decomposing organic matter with detectable sulfur smell from the standing water.

The cause of this type of disease is attributed to various factors. In Ceylon and China, it is attributed to the existence of high concentration of ferrous iron which is invariably found in places of high water table. Opinion is however divided on the effect of lime. In Ceylon, it was shown that iron contained in the leachate was greatly decreased by the application of lime and in field experiments, application of lime increased the yield in the affected area by as much as 1,000 kg/ha. In Taiwan, on the other hand, though affected rice plants were found to contain more iron than the normal ones, no effect of lime was observed on the yield of rice plant. The differences may be attributed to the difference in soil pH. In Ceylon the affected soils have a range of pH from 4.3 to 4.9, and in Taiwan from 5.8 to 7.5. Generally speaking, when reaction of the soil is towards alkaline side, iron changes from the ion form to sol form, and it is the ionic form that is known to be more toxic.

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In Japan, disease of paddy under reductive conditions has been attributed to the hydrogen sulfide which is formed by the reduction of sulfate or the decomposition of organic matter. However, this is restricted only to soils low in free iron content.

In places where water table is high and internal drainage is poor, iron content of the soil is generally high. In such cases, disease cannot be attributed to hydrogen sulfide toxicity. Cause in such cases is attributed to 1) formation to low molecular organic acid, such as formic, butyric, acetic and others, 2) formation of ferrous iron and 3) lowering of Eh itself.

In places of poor drainage, it is frequently observed that iridescent film of iron is formed on the surface of the water, and colour of the soil is bluish, which show the presence of much ferrous iron and decomposing organic matter. Without the presence of decomposing organic matter, ferrous iron cannot remain in the soil solution against the diffusion of oxygen from the atmosphere. When organic matter is present, its decomposition in the soil is anaerobic and organic acids are formed to some extent. Some of them have been proved to be toxic in water culture, if present in considerable quantities. Analysis of affected soils revealed that they may be sometimes present to such an extent as to be toxic to rice plant. However, amounts found were generally below the level of toxicity.

Toxicity of ferrous iron

Toxicity of ferrous iron has been shown by the water culture technique. The results of a water culture experiment conducted in Malaya recently with chelated iron, showed that ferrous iron was very toxic to the rice plant at a level of 50 ppm. Soil analysis made in Japan and Ceylon shows that the ferrous iron content can be higher than this level, and injury may be attributed to this cause. However, the symptom of rolling in of the leaves caused by iron toxicity is not found in Penyakit Merah.

An experiment conducted this year in Japan revealed that iron present in the soil solution is not so toxic as that contained in the culture solution. This experiment was made in specially devised apparatus to keep the roots dipped in the clear leachate without access to atmospheric oxygen. Decrease of toxicity of iron is considered to be due to the existence of some organic substance such as sol of humus, which may be in the chelated state with iron, or it may be explained by the difference of the form of iron itself, such as sol or ion.

Supply of oxygen

Paddy roots consume free oxygen of the culture solution and lowers its partial pressure to nearly zero, even when the culture solution is in contact with atmosphere. The reason why paddy roots grow well in such a condition without aeration, is that the rice plant has special oxygen conducting system from the aerial portion of the plant to the roots. This is demonstrated by the fact that excised roots of paddy require free oxygen for their functioning just as those of barley. There is the possibility that free oxygen before it can diffuse to the active part of the root is made unavailable by the reductive substances of the soil, such as ferrous iron and

manganous manganese. In poorly drained places paddy roots are stained reddish brown by the incrustation of ferric iron, though the soil as a whole is very reductive, showing bluish colour.

It is often observed that the ramification of roots is poor in reductive soils, e.g. in Ceylon, China, Japan. It was also observed in Japan that in very reductive peat soils secondary roots sometimes do not protrude through the epidermis, but elongate along the stele within the cortical tissue. This indicates that the actively growing root tip requires a good supply of oxygen. It can therefore be inferred that under highly reductive conditions, soils not only lack free oxygen, but they also render the free oxygen within the plant system unavailable. This results in the poor functioning of the roots, thereby inducing K or P deficiency as the absorption of these elements is more dependent on the metabolic activity of the roots than is the case with other elements.

Loss of the function of Fe and Mn as oxygen carrier

It is well known that Fe and Mn undergo valency change. If the paddy field has good internal drainage, these two elements absorb oxygen during off-season, and, after flooding, they prevent the soil from becoming too reductive by releasing the combined oxygen. This function of the two elements as a poising agent for Redox potential is entirely lost in soils under stagnant water. They remain in ferrous and manganous state all the year round and the soil is liable to be too reductive.

Accumulation of easily decomposable organic matter

Affected soils may differ greatly in their total organic matter content. However, they probably have a higher proportion of the easily decomposable organic matter, because under anaerobic conditions decomposition of organic matter goes on slowly. Peat on well drained site has comparatively small amount of easily decomposable organic matter though much of it is composed of organic matter. On the other hand, sandy soils under stagnant water contain a considerable amount of easily decomposable organic matter though total organic matter content is low. (By easily decomposable organic matter, the author refers to that portion of organic substance which decomposes on slight changes of the environment, such as air-drying the soil or raising the soil temperature from 30° to 40°C.)

Morphological features of the rice root

When rice seedlings initiate roots, cortex is well filled with cells, though intercellular spaces are better developed than those of barley or wheat. Later, cortical cells almost die away and space between epidermis and stele is considered to act as oxygen conducting space. The reason for the likelihood of the disease appearing at tillering stage is attributable to the poor development of the conducting system at the earlier growth stages. It is also known that secondary roots have less developed air conducting cavity. This explains somewhat the poor branching under reductive conditions.

In short, the accumulation of easily decomposable organic matter under stagnant water with the inevitable results

such as the formation of excessive amount of ferrous iron, toxic organic compounds and oxygen starvation of root, is considered to be the basic condition for the occurrence of the disease. Furthermore, the consequent poor functioning of the roots also results in deficiency symptoms as reported from Japan, Malaya and Indonesia. Which particular cause is the most important, may be determined by climatic and soil conditions. Iron content may vary according to soils. Easily decomposable organic matter content and its decomposition rate may differ according to temperature. In this respect, the report from Malaya is considered very important. "Investigations have also shown that there are several conditions which go by the name of penyakit merah, and that the symptoms in each of these differ to such an extent that there is every likelihood that several causes may be found".

From the academic point of view, further detailed studies are required. However, from agronomic point of view, the problem is considered as nearly solved. The concensus of the opinion of experts of the countries concerned is that the disease can be controlled by drainage. Possibly, this is the best way of solving the problem. Unfortunately, however, the disease is always found in the low level regions of the paddy growing area. Unless elaborate measures are taken to construct an efficient drainage system, it is difficult to achieve the objective.

However, where this is not possible the following measures are recommended:- 1) draining the water as far as possible, 2) addition of soil, 3) withholding applications of organic manure, 4) making ridges to oxidize the soil, 5) adoption of resistant varieties. If some or all these measures are taken the development of high reductive condition in the soil can be checked to a great extent.

Other diseases are those reported from Thailand and Cambodia, Straighthead reported from the United States and Aodachi, Akiochi Hideri-aodachi and Aogare from Japan, Myit-po and Yellowing from Burma.

The cause of the diseases reported from Thailand and Cambodia, is attributed to the low pH of the soil. The report from Thailand states that the abnormality is shown by the stunted growth both in the transplanted and broadcast rice from the early seedling stage to maturity. Severely affected plants die either during the middle or later part of the rice growing season. Those that remain stunted either produce few grains or none at all and the plants usually do not produce any tillers. Affected plants are usually found on the Ongkarak clays which are very acid soils ranging in pH from 3.5-4.5. The disease is attributed to aluminium toxicity. The application of lime somewhat alleviates the disease, but because of the general impoverishment of soil, the yield is very poor. The area affected is about one-third of the whole Bangkok plain.

In the case of the disease reported from Cambodia, which is locally called "Kra", though many other diseases are also called "Kra" by the cultivators in that country, the area affected is estimated at about 20,000-30,000 ha. varying somewhat from year to year. Varieties are indica, non-glutinous lowland paddy and the symptoms of the disease appear mostly at the tillering stage. The disease

is suspected as due to low pH in sandy soils. The disease appears in the test plots where some amounts of ammonium sulphate are applied (150-300 kg/ha). The use of farmyard manure (or green manure 2 or 3 weeks before transplantation) seems effective in sandy soils. Incidentally, water culture experiment made in Malaya revealed that Al was not toxic to the plant up to the concentration of 4 ppm which was the highest concentration applied in the experiment. In Japan, it was found that Al was not toxic up to the level of 5 ppm as Al_2O_3, slight damage was caused at 25 ppm Al_2O_3, and plant injury was greatest with no grain formation at 50 ppm.

As for Myit-po in Burma, it is fortunate that the remedial measure by application of phosphate is already known. Yellowing in Burma seems to be related to manganese deficiency, as it can be corrected by the application of sulfate containing chemicals. In Japan, Yellowing due to manganese deficiency is a frequent occurrence in upland paddy and at least in one location in the case of wet paddy. It can be remedied by a high application of sulfate of ammonia, or fresh organic matter, which makes Mn available to paddy.

As for Akiochi in Japan, it is different in that it occurs on well-drained sites and the symptoms begin to appear only about the heading stage, while earlier growth is normal. The cause of this trouble is also due to the reductive conditions of the soil. Formerly Akiochi was exclusively attributed to the toxic action of hydrogen sulfide. Now it is widely accepted that the disease is also related to the deficiency of silica, magnesium and other bases as in the "degraded soil". The disease was fully studied because of its wide occurrence, affected area amounting to 600,000 ha. Nowadays, the disease can be almost completely overcome if cultivators have the will and resources. Recommended measures are 1) avoidance of the application of sulfate fertilizers, 2) application of furnace-slag (chief component being calcium silicate) at the rate of about two tons per ha., 3) deep-plowing or subsoiling to bring back the leached substances to the top, 4) adoption of resistant varieties, 5) heavy dressing of well-rotten farmyard manure and 6)application of well balanced NPK fertilizers.

Straight-head in U.S.A. can be prevented by drainage and drying the soil just prior to initiation of reproductive stage. However, finding that the draining practice is not economical, effort is now directed to breeding resistant varieties. The disease is liable to occur in places of poor drainage and high organic matter content. High reductive soil conditions may perhaps be a cause.

Aodachi in Japan, which is comparable to straight-head in U.S.A. occurs in places where land previously cropped with upland crop is first turned to paddy. The disease is also attributable to the development of too reductive soil conditions at the intermediate growth stages of the crop. Naturally, the soil Eh is higher than the ordinary paddy field at first, but later it becomes lower than the normal one.

Aogare in Japan which has been noticed recently appears at the late stages of growth, usually past the milk stage of the grain. The disease is supposed to be due to early draining of the soil and

the disease could be prevented by delayed draining. Affected soils are coarse in texture. An excess of nitrogen with deficiency of potash is liable to induce the disease. Further studies are in progress.

Akagare-affected plants are deficient in K, yet they cannot completely be cured by heavy dressings of K. In the recovery stage the potash content of the affected plants approaches that of the normal ones even without any dressing of K. In connection with the penyakit merah, it is suspected in Malaya that adverse soil conditions retard absorption of P.

In Indonesia, it was found that areas with frequent occurrence of crop failures due to mentek correspond with areas responsive to phosphate fertilizers.

Conclusion

1) The author feels that, with the exception of the diseases reported by Thailand and Cambodia, both of which have not yet been fully studied and Yellowing and Myit-po in Burma, all the physiological diseases so far noticed and studied are more or less related to the development of "high reductive conditions" of the soil. Critical point of reduction may be somewhere around Eh_{6-100} Mv at least as far as the appearance of Akagare and formation of hydrogen sulfide are concerned.

2) Substances responsible for the disease are considered to be one or more of the following: ferrous iron, manganous manganese, hydrogen sulfide, butyric acid, formic acid and so on. There are some indications that the specific substance is different according to soil and climatic conditions.

3) The diseases, with the exceptions above-mentioned, can be cured, prevented or at least alleviated by external or internal drainage.

METHOD OF REDUCING THE NUMBER OF VARIETIES IN THAILAND

Sala Dasananda[1]

In the program for rice improvement, a very large number of varieties have to be examined by suitable trials for eliminating the poor yielders and selecting a few superior varieties. The chances of getting these will depend on the volume of material handled and efficiency of selection methods.

A great number of varieties are still grown in countries where rice was in cultivation from ancient time. Dr. Love of Cornell University when he first started rice work in Thailand in 1950 laid down a program for rice improvement which has led to a considerable reduction in number of varieties as well as to the establishment of superior varieties with greater adaptability. The program is accomplished in three stages:- (1) Selection, (2) Variety tests and (3) Regional trials.

Selection

In following a hybridization program or panicle collection from varieties, usually thousands of lines will have to be grown at the start for examination. The first step followed is *selection*. Each line is grown in a single row with a row of standard variety inserted at intervals of every tenth row as a check for comparison. In the first year, these lines are not replicated and yield is not recorded. Selection is made by visual observation in comparison with check. In the second year each line is grown with three replications and selection is based on yield records in comparison with check. In subsequent years, six replications are given for each line. After 4 or 5 years of screening for yield, only a few hundreds of lines with desirable characters such as yield, grain size and quality, maturity, etc., are retained.

Variety Test

The few hundred lines or varieties are then put under test in groups of about 40 varieties according to type (glutinous or non-glutinous) and maturity with at least one appropriate standard variety as a check for each group. The three – row plot, six – replication randomized block design is used throughout for these tests. These tests are carried out simultaneously both in main rice station as well as in the different experimental stations in the regions. The average of three years' yield results of these variety tests along with the notes on desirable characters are taken into consideration for the selection of superior lines or varieties for regional trial.

Regional Trial

The purpose of the regional trial is to find the adaptability and performance of these top varieties in the wide area of the region. These regional trials are conducted in the farmers' fields scattered in the area where some of these varieties

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would finally be recommended to the farmers.

Thailand is geographically divided into 4 main regions: (1) the North, where the glutinous type of rice predominates, (2) the Northeast, where the glutinous type predominates in the northern part and the non-glutinous type predominates in the southern part, (3) the Central Plain, or the Rice Bowl of Thailand, where the non-glutinous type is commonly grown, (4) the South, where the non-glutinous type also predominates. Each region comprises a rather large geographical area, especially the Central Plain and the Northeast, with about 16 million hectares each. The North and South regions are about 8 million hectares each.

To find the performance of these top 18-20 varieties in each area, several factors have to be considered, such as maturity, grain quality, rainfall and availability of water, soil type, and other climatic conditions.

It would be ideal to find one variety that could cover all the areas, but that is not usually possible. However, some varieties are found to do well in a fairly wide area. This is the kind to look for, for recommending to farmers. With this aim in view and considering the factors mentioned earlier, varieties are grouped for regional trials: 1) The North group, mostly of glutinous type short grain of early-medium maturity, 2) The Northeast I group, covering the Northern part of the Northeast region, mostly of glutinous type, long grain early-medium maturity, 3) The Northeast II group, covering the Southern part of the Northeast region, mostly of non-glutinous, long grain, early-medium maturity, 4) Central I group, covering the lower middle portion of the Central region, all medium–late, non-glutinous, long grain type, 5) Central II group, covering the periphery of the Central region, all non-glutinous, long grain type of early-medium maturity, 6) The South group, all non-glutinous, long grain type and late maturity.

The number of trials in each group, ranging from 15 to 40 trials, depends upon the area covered and also the number of rice officers available.

All these regional trials are conducted by local rice officers who work as rice extension agents in the Provinces. In choosing the locality for such regional trials, the following points are to be considered: (a) The localities should be scattered throughout the area as much as possible, (b) The locality selected for the test should also be a good representative of the surrounding area.

As mentioned above, only the top best 19 or 20 varieties from the Experiment Stations of each region, are taken for the regional trials. One or two earlier recommended varieties of the area are included as checks. Each rice extension officer who conducts the regional trial, will also add 4 or 5 local popular varieties for comparison, making a total of 25 varieties in each trial. The design used is a 3-row plot, 6-replication randomized block. At the end of the season, the data is sent to the Central Statistics Section of the Rice Department for analysis. Each year, a new batch seed of the station varieties is sent to the rice extension officers from the Experiment Station for trials in the succeeding year.

In a series of regional trials in the Northern part of the Northeast area conducted over a period of three years 1956-58, the tests were conducted in 26 localities spread all over the region. Each test consisted of 21 experimental station varieties including 2 earlier recommended varieties as No. 3 and No. 8 (Table 1). In each locality 4 local popular varieties were included as local checks. The names of these are not given in the table as they varied with the locality. The average yield for 3 years for selection for each locality is tabulated and the Table 1 gives the summary average for all the localities for the trial conducted during 3 years. From the table it can be seen that variety number 13–Daw Nahng Nuan, a glutinous variety whose harvesting date is 26th November is highest in yield. It possesses a good grain quality and is recommended for multiplication for distribution to the farmers. Variety No. 2–Gow Ruang, the second best, even though it has a high yielding ability, is rather poor for grain quality and was dropped from recommendation by the varietal committee. Variety number 8–Leuang Yai 34 ranking third, is an old non-glutinous recommended variety and since another variety of the same maturity to match its performance in both yield and quality is not available, its recommendation is still continued. Variety number 5–Leuang the fourth ranking variety is also non-glutinous of the same maturity age and grain quality as Leuang Yai 34. Therefore, it is not included for recommendation. The fifth ranking variety, number 4–Khao Dawk Mali, non-glutinous, which yields slightly less than number 5 and number 8, possesses a high grain quality and is recommended for multiplication because it is about 7 days earlier than Leuang Yai 34. Variety number 3–Muang Pai, an old recommended variety has the same harvesting date and grain quality as Khao Dawk Mali and since its yielding ability is lower than Khao Dawk Mali, it has been dropped.

To sum up, only three varieties are recommended out of these trials for the North part of Northeast Thailand from several thousand lines selected in 1950. Some of the remaining varieties in the regional trials, which possess special quality and high yield, drought, and disease resistance are put in the collection to be used in the future hybridization program.

It may be pointed out that these regional trials also provide data regarding the performance of the recommended varieties in comparison with the local popular varieties in the region. The average increases in percent of all the station varieties, four best station varieties and the highest four of the station varieties at all the locations over the local popular varieties are 4.25%, 11.49% and 18.30% respectively. The yield increase of the 3 recommended varieties No. 4, No. 8, No. 13 over the popular farmers' varieties is 10.9% in this region. The best recommended variety–No. 13 (yield 1675 kg/ha) gives a gain of 14% over the average of local popular varieties.

In order to give some idea of the various phases of work in the project, a brief summary of the work load of the year 1958 is presented in the following table (Table 2).

TABLE 2

Region	Northern	Northeastern	Central	Southern
No. of selection	5,130	39,000	21,211	1,214
No. of varieties tested in station	291	438	1,320	89
No. of regional trials	21	26	54	5
Recommended varieties[1]	3	3	9	—

To find out the adaptability of the recommended variety, a map is prepared of the region showing the locations of the tests and marking the top three varieties in each location. This will give a picture of the range of adaptability of the varieties and also serve as a guide for the recommendation of a particular variety in a given area. For instance, from such a map prepared for Northern area, on the basis of the tests described in the paper, it was found that variety No. 4 did well in the northern part of the region. Variety No. 13 had a wider range of performance covering diagonally the area from Northeast to Southwest and also along Southeast area and variety No. 8 was good both in Northwest and Southeast range.

These regional trials gave a clear picture of the range of adaptability of the varieties in a certain area and served as a guide in making recommendations and also limited the number of varieties recommended to a minimum. It is impractical to recommend too many varieties to the farmers in an area. Furthermore, these regional trials create quite an interest among the farmers. The rice agents could explain the purpose of these trials and the farmers are convinced of the performance of the newly recommended variety.

1 *One recommended variety is common for both North and Northeast. The Central region includes 4 floating varieties.*

TABLE 1

Giving the average yield in trials conducted in 26 localities in North East region during 3 years (1956-58)

Variety No.	Name of variety	Harvesting date	Yield kg/ha.	Ranking
1	Khao Bahn Dawn	19 Nov.	1537	10
2	Gow Ruang	20 ,,	1644	2
3	Muang Pai	23 ,,	1500	14
4	Khao Dawk Mali	23 ,,	1587	5
5	Leuang	29 ,,	1600	4
6	Leuang Yai 16	1 Dec.	1556	7
7	Leuang Yai 157	3 ,,	1569	6
8	Leuang Yai 34	1 ,,	1625	3
9	Niaw B-T	26 Nov.	1494	15.5
10	Pamah Yai	24 ,,	1537	10
11	Mae Rahng	25 ,,	1462	17
12	Daw Leuang Nam Pueng	25 ,,	1537	10
13	Daw Nahng Nuan	26 ,,	1675	1
14	Man Ped	27 ,,	1531	12.5
15	Daw Hawm	27 ,,	1550	8
16	Niaw Leuad Haed	28 ,,	1531	12.5
17	Pah 23	4 Dec.	1400	19
18	Lai Luang 17	4 ,,	1344	21
19	Gaew Khao 11	5 ,,	1494	15.5
20	E-Sey	4 ,,	1444	18
21	Khi Tom Khao	3 ,,	1387	20
22	Non-Glutinous	..... Local Varieties		
23	Glutinous			
24	Glutinous			
25	,,			

	Average for All Tests	Average Increase over Farmers' Varieties kg/ha.	Percent
Station Var. 1-21	1531	62	4.25
Farmers' Var. 22-25	1469	–	–
Var. 2, 5, 8, 13 @	1637	169	11.49
Highest 4 out of 1-21 at each location	1737	269	18.30

FINAL REPORT ON THE INTERNATIONAL RICE HYBRIDIZATION PROJECT[1]

Introduction

The International Rice Hybridization Project was discussed at the meeting of the 1st Working Party on Rice Breeding at Rangoon (February 1-4, 1950) and was recommended to the IRC as "a promising means of securing varieties containing the most valuable qualities which are characteristic of each group". On the approval of IRC, sanction for the conduct of the project for a period of 3 years was received from FAO in July 1950 and the scheme was put in to operation in August 1950. The scheme was later extended up to the end of March 1956 by the IRC on the recommendation of the Working Party at Bandung, 1952. At the second meeting of the Working Party on Rice Breeding held at Bogor, Indonesia during April 1951, the aim of the project was specified as "for combining the high fertilizer response of japonica types with the hardiness and adaptation to the tropical conditions characteristic of indicas."

Initially the project started with the participation of Burma, Ceylon, India, Indonesia, Indochina, Malaya, Philippines and Thailand. During the course of the project, Pakistan joined in 1951 and later Australia in 1954. During this year, Cambodia and Vietnam took the place of composite Indochina. Egypt though not a regular participating country, was supplied with hybrid seed, at the request of Dr. L.E. Kirk lately of FAO.

Description of the Project

The project was conducted at the Central Rice Research Institute, Cuttack with the cooperation of the Government of India. Indica varieties chosen by the participating countries were crossed with japonica varieties obtained from Japan through the courtesy of Dr. T. Morinaga. Out of the 15 japonica types grown, the hybridization was confined to 8 types in view of the unsuitability of the rest due to very early flowering, poor germination, etc. The F_1S were grown at Cuttack and F_2 seed of the respective crosses was sent to the participating countries for selection under the local conditions. In the first stage of the program, 33 indica varieties were crossed with 8 japonica varieties making 264 cross combinations. In view of considerable amount of sterility in the F_1S ranging from about 45-85% and that only certain few combinations were fertile, it was decided to increase the chances of getting fertile hybrids by increasing the number of indica varieties and crossing with japonica varieties known to give fertile combinations. Two japonica varieties, Fukoku and Zuiho suggested by Dr. Morinaga were crossed with 63 indica varieties sent by the participating countries, giving 226 cross combinations under the extended program. In view of the inadequate knowledge on hybrid sterility in japonica-indica hybrids, work on the cyto-genetics of F_1 hybrids was taken up by appointing a cytologist in the

1 *Compiled by N. Parthasarathy, Regional Rice Improvement Specialist of the FAO, from the reports of the participating countries.*

scheme. Back-crossing the highly sterile hybrids with the respective indica parents was also included in the extended program to provide the back-crossed seeds to the participating countries.

In India a parallel project was given effect to, with the aid of the funds from the Indian Council of Agricultural Research (I.C.A.R.). In addition to 4 indicas of Cuttack included in the FAO scheme, 97 indica varieties supplied by the rice growing States of India were crossed with japonicas giving 320 combinations. F_2 seed of these hybrid combinations were sent to the States for selection under the local conditions.

The japonica parents were all early, taking 58-70 days from sowing to flowering while the flowering of indicas ranged from 90-150 days. Two methods were adopted to synchronise the flowering of japonica and indica parents: (1) restricting the day length hours to 8 hours to 30 day old seedlings of indica parents for a period of 3 weeks and (2) planting of japonicas every 15 days all the year round. The manual method of using forceps for opening the glumes and removing the anthers for emasculation was followed. The F_1 plants were grown along side the respective indica parents for comparison, while the japonica parents were not grown in view of their very poor growth under the local conditions. F_2 seed collected from the F_1 hybrids were despatched to the participating countries, the first batch in 1952 and 1953 and the second batch in 1954 and 1955.

At the 4th meeting of the Working Party on Rice Breeding and subsequent meetings, the participating countreis reported on the progress that was being made in the selection program and based on the experience recorded and discussion, recommendations were made for adoption. At the meeting at Bangkok in 1953, it was recommended that as large a population as possible should be grown in F_2 and that wherever the available facilities permit, progeny selection should be adopted and at least 100-200 progenies in each cross should be carried forward. In addition, the remainder of F_2 material could be bulked separately for each cross and carried forward 2-3 generations as a reserve for possible further selection. It was also recommended that "material should be grown under normal fertility to begin with, and under ordinary and high fertility conditions in the later stages to bring out the responsiveness of selections to such conditions". At the next meeting held at Tokyo 1954, suggestions for further conduct of selection were given in the recommendation "that in order to retain and permit recognition of selections capable of responding to heavy dressings of fertilizers, the material should be grown under high soil fertility conditions from the F_2 generation onwards".

Sterility in F_1 Hybrids

Data collected at the Central Rice Research Institute on the F_1 hybrids relate to the following:

1) The F_1 plants were very vigourous and exhibited considerable heterosis with regard to plant height and number of ears per plant. In grain yields the hybrids were generally inferior to the indica parent which was due to the

high degree of sterility, average sterility being 60-70% in most of the hybrids. Where the sterility was low, the hybrids were superior in grain yield over the respective indica parents.

2) The spikelet sterility in the F_1 hybrids varied from 15% in a few hybrids to as high as 99% with the mean of 60% for the cross combinations. The pollen sterility however was a little lower than the corresponding spikelet sterility and ranged from 7% to 82% with a strong positive correlation of $r = +0.815$ between the two.

3) In general, there was no difference in the sterility percentage in reciprocal crosses, but in certain cross combinations, the difference in sterility was significant indicating the influence of cytoplasm on sterility.

4) The sterility data on F_1 hybrids were analyzed to get information on (a) the relationship between country averages of the indica varieties and (b) comparison of the different japonica parents in regard to sterility in the different cross combinations and (c) maturity group of indica varieties and sterility.

5) In the initial program very few indica varieties from each country were used as parents and it was found Ceylon varieties gave a lower mean sterility than the varieties from other countries. In the extended program where a relatively larger number of indica varieties entered in the cross combinations with two japonica varieties, Fukoku and Zuiho, hybrids with varieties from Pakistan gave relatively a lower value. These latter two japonica varieties were included in the extended program as it was considered that they would give more fertile hybrids with indicas than the original 8 japonica varieties used for hybridization in the initial program. The results however proved that these two japonicas were no way different from the previous ones. While there did not appear any definite trend between maturity group and sterility in the cross combinations of the initial program, in the extended program involving Zuiho and Fukoku as japonica parents, it was found sterility was low in *aus* hybrids.

6) The extent of sterility in F_1 depended on varietal interaction. In the hybrids with Indian varieties, A.D.T. 12, G.E.B. 24 and T. 812, the sterility was uniformly high, while in T. 1145 hybrid the variation was from 46 to 95%. Variety Guiningang of Philippines gave a uniformly high sterility of 90 to 99% in all the 8 cross combinations, while in $D_{25\text{-}4}$ of Burma the sterility range was from 11-42%. There are hybrids with other indica parents which also gave varying degrees of sterility, e.g. Vellai Illankalyan 41-74%; Patna 33, 48-49%; Doc phung Lun 45-80% and so on.

The high sterility of F_1 hybrids, raised doubts at the start as to the future success of the project and as a possible measure of overcoming the sterility, back-crossing the highly sterile F_1 hybrids to the respective indica parents was taken up at the Central Rice Research Institute as an item in the extended program. In all, 31 combinations of B.C. 2 seed material were sent to the participating countries. So far, no country has reported any success with this material except Vietnam. In Mandalay, South Burma, the progenies now grown from

this material are uniform and resemble the respective indica parents. At Hmawbi, the progenies are still segregating and 32 plants have been selected during 1957-58 season. In back-crossing, the indica parent had been used as the female and evidently, the B.C.2 seed in some cases were only selfed seed of the indica parents.

In the project for India sponsored by the Indian Council of Agricultural Research, Madras is the only State which has reported any results. Trials of 6 progenies in back-cross material with G.E.B. 24 as the recurring parent and 142 progenies with A.D.T. 12 as the recurring parent are now in progress and most of these are pure breeding with high spikelet fertility, and some of these are better in yield performance than the respective parents.

In the many cross combinations the high sterility of F_1 hybrids did not prove to be a handicap as there was enough scope for selection of plants with high fertility in the succeeding generations and fully fertile progenies have been obtained in the later generations in the participating countries. The study of segregation of sterility in F_2S and F_3S indicated that inter-racial sterility was mainly governed by genes and the steady progress in fertility in later generations could be explained on the basis of elimination of infertile combinations. The effect of environment also affected the expression of this character as it was noticed in Indonesia that sterility of the hybrids was more marked in north Sumatra than in Java. Similarly, there were considerable differences in sterility in the same progenies grown in North and South Malaya. At Cuttack, it was found that sterility in the same cross combination was much higher in the second crop season than during the main season on account of high temperature and lower humidity conditions prevailing during the flowering time in the second crop season. In North Australia also, it has been reported that sterility is more in summer season, (November to April), than in cold, dry winter season (April to August). Cyto-genetical investigations on the chromosome pairing during reduction division indicated that it was regular though at anaphase there were irregularities like occasional laggards, chromosome bridges, etc. and these could not however completely account for the high degree of sterility in the F_1 hybrids.

Progress of Breeding in Participating Countries

The number of cross combinations of F_2 seeds sent to the different countries and the number of indica varieties used in such crosses as well as the average population grown for each combination together with the selection scale in the F_2S are indicated in Table 1. From the available data, it would appear that generally homozygous lines were obtained in F_6, for characters like flowering time, height, grain size, habit, etc., but in some cases considerable heterozygosity for the above characters was found even in F_7 and F_8 generations. Preliminary row yield tests were taken up from F_6, but in some countries such yield tests were not taken up till F_8 and or even F_9.

Burma

Selection work is still in progress at Hmawbi, South Burma and Mandalay

in North Burma. At Mandalay 71 F_3, 42 F_4, 2 F_5, 51 F_6, and 22 F_7 lines were grown under irrigated conditions in 1957. Of the 22 lines in F_7, one line from cross $C_{28\text{-}16}$ × Aikoku and another from $D_{17\text{-}88}$ appeared promising. Few lines from Norin 8 × $D_{17\text{-}88}$ were found to be good. Plant selections are being made on the basis of row yields. All the lines in F_7 and F_6 were under preliminary row yield tests.

At Hmawbi, 86 F_7 lines were more or less homozygous and were grouped according to grain grades and maturity groups and were tested against respective standard strains in randomized blocks with basic fertilizer application of 22.4 kgs. of N and 22.4 kgs. of P_2O_5 per hectare. A few of C and D type line cultures were found to be equal to the standard strains in yield, and the quality of their grain was much better than the standard strains. The parentages of these lines are: i) $C_{24\text{-}102}$ × Rikuu 132, ii) $C_{28\text{-}16}$ × Aikoku, iii) $D_{25\text{-}4}$ × Asahi and iv) $C_{24\text{-}102}$ × Norin 17.

174 selections have been made from F_3 to F_6 progenies for further trials. The preliminary yield tests are being conducted from F_5 onwards. 25 lines cultures, selections from F_6 in bulk progenies were still found to be segregating and out of these 16 plants from F_6 and 17 from F_5 bulks have been selected for further study.

Indonesia

Out of 38 cross combinations received by this country, 81 lines from 7 cross combinations were put to preliminary yield trials in 1957-58 season. Of these only 3 lines were found to be suitable for final yield tests which were conducted in randomized block with 4 replications with the local strains Ramadja and Djelita as checks. The 3 lines are from cross combinations (a) Norin 20 × Bengawan, and (b) Norin 8 × Myang-ebos. It was found that all the 3 lines yielded less than Djelita while one from Norin 8 × Myang-ebos was equal to Ramadja in yield. The tests were carried out in plots fertilized with 40 kgs. of nitrogen plus 20 kgs. of P_2O_5 per hectare.

Malaya

The selections from the cross combinations received first from Cuttack are now in F_9 stage, and the combinations received last are now in F_5 stage. Both bulk and progeny methods are followed and now the number of line cultures for further work in 1959-60 is 196 at Telok Chengai, North Malaya, 530 at Pulao Gadong in South Malaya and 1242 at Bukit Merah near Penang. Ear-rows in the advance generations have reached the high degree of homozygosity, although there are still a few segregating lines from which outstanding plants have been selected before such lines were discarded. Plant yields have progressively increased over the preceding generations and despite the adverse conditions during 1958-59 season, most plants selected gave yields of over 100 grams per plant as compared to 50-70 gram yields of the respective indica parents. The work of isolating low-photo sensitive selections for double cropping have been in progress at Bukit Merah since 1955 and with the acquisition of the services of the Colombo Plan Japanese expert Dr. Yamakawa in 1958, the work of synthesizing period fixed, high

yielding, short straw varieties was further expanded. Pedigree lines have been established and selections of strains suitable for double cropping are being tested both in the main and in the second season.

East Pakistan

Selections from F_3 generations were from field fertilized at 67 kgs. of nitrogen per hectare and 44.2 kgs. of P_2O_5 per hectare. 60 pedigree lines from 9 cross combinations with *aus* varieties, 77 lines from 22 cross combinations with transplanted *aman* and 15 lines from 4 cross combinations with *boro* varieties are to be put under preliminary yield tests this season. Selections have been made for erect habit, fertility, height, tillering and yielding capacity. In the early generations the individual selected plants gave 2 to 3 times the yields of indica parents but in later generations this superiority was not maintained.

Philippines

Selection work is in progress in 2 locations, one at Maligaya under low land conditions and the other at Los Banos under upland conditions. At Maligaya Experimental Station, the selections were made under field manuring at the rate of 100 kgs. of nitrogen per hectare. From the first batch of seeds of 6 cross combinations received during 1952, 36 apparently homozygous lines were put to preliminary yield tests during 1955 to 1957. Out of these, four were selected as promising and were tested for regional adaptability in 5 locations in 1958. These were from cross combinations, Norin 1 × Elon-elon. The check varieties used were the Seed Board recommended varieties BE-3 and Peta. Out of these on an average, the culture Nor-elon 340 was found comparable to the checks and actually in three locations out of 5, this culture out-yielded the checks. No comparison has been made with the indica parent Elon-elon.

At the UP College of Agriculture, Los Banos, Laguna, the hybrids were grown under upland conditions in 1955. A total of 1055 F_4 line selections from 14 crosses were grown under replicated single row plots with 2 standard varieties. Fortuna and Kinandang-puti planted to every 20 rows and tested under high fertility conditions. A total of 21 F_5 lines from 7 different crosses were grown in 1956 for yield tests and out of these, 4 lines (F_6) were selected and yield tests during 1957-58, 1958-59 indicated that one line, that is Thailand × Norin 6 was as good as the check and this was again included in the test for 1959.

Thailand

Selection work was started in 1952 both at Bangkhen Central Region and San Patong, North Region, and from next year the work was confined to San Patong. The selected progenies are now in different stages of selection from F_5 to F_9. 12 F_9 lines have been put to yield tests this year. Out of these, 5 lines are progenies from crosses where Rikuu 132 is one of the japonica parents. From F_5 generation, 14 plants have been selected for head-rows and 237 from F_6 to F_8 are still under row trials. So far, no yield data has been recorded and selections are made on grain size and quality requirements of the country. Selections are all along being made under normal fertility conditions.

Vietnam

Selection work is in progress at the Mytho Rice Station located 70 km. from Saigon and the hybrids are now grown under fertilizer application of 30 kgs. of N plus 50 kgs. of P_2O_5 + 15 kgs. of K_2O per hectare. During this year the selections were from F_5 to F_8 stages, and even in F_8 some of the lines were found to be still heterozygous. The total number of lines under study is 136. The cross with japonica parents, Taichung 65, Norin 8 and Asahi gave better progenies than the rest. From among the back-crosses sent to this country, one line from (Taichung 65 × Neangmeas) × Neangmeas was found to be promising and this is being tried in several locations. It is doubtful if the line is the same as Neangmeas parent and this would be checked carefully during this season.

North Australia

From the first batch of seeds sent during 1955, 17 uniform lines have been selected for short japonica grain size at Kimberly Research Station and these were found to be suitable for the winter season. In the winter season generally the japonicas are grown. Some of these lines were found to be responsive to fertilizer application of 100 kgs. of nitrogen plus 50 kgs. of P_2O_5 per hectare. From the second batch, selections are still in progress for suitability for growing in the summer season for which indica type of varieties are required. There is a real need for short strawed non-lodging indica grain types which would respond to high fertilizer application and it is reported that there are indications that this objective might at least be partially achieved.

India

At Central Rice Research Institute, Cuttack, F_2 population of 32 cross combinations involving 30 indica parents from 6 Asian countries and some States of India was grown under normal fertility conditions (45 kgs. of nitrogen per hectare) and F_3 were raised under two levels of fertility (1) normal fertility = 45 kgs. of nitrogen plus 20 kgs. P_2O_5 per hectare and (2) 67 kgs. of nitrogen plus 40 kgs. of P_2O_5 per hectare. Besides characters like habit, fertility, tillering, the main character on which selections from F_2 was made, was individual plant yield. F_3 generations were raised in replicated progeny rows and it was found from yield data that the mean plot yield of F_3 cultures under two levels of soil fertility was 24.3% and 37.3% greater than the respective indica parents at the corresponding levels and consequently a greater number of high yielding selections was available at higher fertility level. Correlation study both in F_2 and F_3 population indicated that yield was correlated with plant height, $r = +0.47$ and more strongly with number of ear bearing tillers $r = +0.85$ and with number of grains per panicle, $r = +0.75$. Selection of single plants was continued to F_6 under two levels of fertility and progeny row yield trials were conducted from F_7 onwards when most of the cultures were more or less homozygous, and also bulk yield trials of more uniform cultures were also undertaken from F_7. The results (Table 2) indicated that some of the cultures were higher yielding at normal fertility level than the respective indica parents, or under high fertility they were found either equal to the indica parent and in some cases even inferior.

The succeeding bulk trials in 1958-59 were therefore conducted only at normal fertility and out of the total of 45 cultures, 9 have given significant increase of yields over the respective indica parents the increases ranging between 29 to 100%. The parentages of the high yielding cultures are

	No. of cultures
i) Norin 6 × G.E.B. 24	1
ii) Taihoku × H.S. 19	2
iii) Norin 18 × B.A.M. 9	1
iv) Rikuu 132 × B.A.M 9	3
v) Asahi × T. 812	1
vi) Norin 17 × A.D.T. 12	1

In the parallel project sponsored by the Indian Council of Agricultural Research for the benefit of the rice growing States of India, 97 indica varieties sent by the different States were crossed with japonicas as in the FAO project and the total number of cross combinations amounted to 320. Pedigree method of breeding was followed in all the States of India except Andamans. Breeding work was done under high fertility from the F_3 generations onwards and the fertility level used was 67 kgs. of N plus 30 kgs. of P_2O_5 per hectare in all the States except Bombay, while at Kerala and Kashmir, it was under two levels of fertility. Results for practical implementation have been reported from Andhra and Orissa States. In Andhra, 3 cultures gave a significant increase of 44-48% in bulk trials conducted over the past two years. Other desirable progenies with non-lodging habit, non-shattering grain character and good grain qualities were under yield test and some of these gave nearly 224% increase over the indica parents. Ten superior cultures are now under test in the famers' fields. The japonica parents, Norin 18, Norin 20, Norin 36 and Rikuu 132 were found to be better combiners than Norin 6, 8, Asahi and Ginbozu.

In Orissa, 2 hybrids No. 6 and 7 from the cross Rikuu 132 × T. 812 are now under district trials. Superior homozygous cultures with short height and profused tillering habit are now under yield test. These are from combinations Norin 20 × T. 1145 and Asahi × T. 812. Selection work is still in progress with good prospects of getting promising cultures in the States of Kashmir, Mysore, Punjab and West Bengal.

Results

From the above general working of the project in the participating countries as well as in the Central Rice Research Institute, Cuttack, where detailed initial observations were recorded in the F_1 hybrids, it is noted that (1) there was a high degree of heterosis in F_1 hybrids in the expression of characters such as height, tillering and single plant yield, the latter when the percentage of sterility was low, (2) F_1 sterility did not prove to be disadvantageous, as selections could be made for increased fertility in the course of the succeeding generations and fully fertile pure breeding lines were obtained later, (3) in no country selection in F_2 was made under high level of fertility, (4) the average F_2 population grown per each cross combination was low in Burma, India, Pakistan and the Philippines, (5) very rigorous selection in F_2 was practised in Cuttack, Indonesia and Burma. Selection was based on individual plant yield from F_2 in India, Pakistan and Malaya, (6) except India, no country has conducted experiments to find the response of final selections to different levels of fertility as compared with the respective indica parents, (7) the final promising cultures are from crosses involving the following japonica parents :-

Australia (winter selections), Norin 6, 8, 18, Rikuu 132

Burma, Norin 6, 8, 18, Rikuu 132, Asahi

India : Andhra, Norin 18, 20, 36, Rikuu 132

Cuttack, Norin 6, 17, 18, Rikuu 132, Asahi, Taihoku

Orissa, Norin 20, Rikuu 132, Asahi

Philippines, Norin 1, 6

Thailand, Rikuu 132

(8) it is found that Rikuu 132 has a greater adaptability as a parent, and (9) the following good qualities have been introduced into the selections: non-shattering, high tillering, non-lodging habit, good quality grain, early maturity, low sensitivity to photoperiodism and higher response to fertilizers under medium level of fertility.

At Cuttack, in 1958-59, F_2 generations of a number of japonica and indica crosses were raised again under two levels of fertility (1) normal fertility = 45 kgs. of N plus 40 kgs. of P_2O_5 per hectare and (2) high fertility = 67 kgs. of N plus 60 kgs. of P_2O_5 per hectare in the field. In the case of the cross Zuiho × T. 141 the same F_2 material was also studied under pot condition in a third treatment with a still higher level of fertility (180 kgs. of N plus 62 kgs. of P_2O_5 plus 62 kgs. of K_2O). Characters such as height, number of ear bearing tillers, percentage of sterility and grain yield were studied for each plant. It was found (Table 3) that the values for the above characters increased remarkably at the highest level of fertilizer application. The plants were grouped in various classes according to grain yield. Under conditions of normal soil fertility, the highest frequency of plants was found in the class 8-16 grams. When the soil fertility was high the class 17-24 grams had the highest frequency and at very high soil fertility the class 41-44 grams. The fact that the frequency of high yielding plants increased with increasing soil fertility indicates that there is a possibility of selecting segregates with high fertility response when the soil fertility is kept at a high level.

The correlation studies indicate the positive correlation between height and yield as reported earlier, and it is therefore possible when selecting for individual plant yield, short straw plants might be left out unless deliberately selected. Short stature plants with good yield were also found occasionally. The above results indicated that the F_2 should have been grown under very high level of fertility to bring out the japonica character of response or selection should have been made at random on a larger scale of at least 10% in F_2 population of at least five thousand plants. In Thailand and Malaya, though a much larger scale of selection was done, F_3S and later generations however were not grown under high fertility conditions.

The aim of the project was to evolve varieties with greater responses to high fertilizer application. The results obtained so far at Cuttack, India, indicate that it has been possible to get varieties which are better responsive than the local indicas only under medium level of fertility, i.e. 45 kgs. of nitrogen plus 40 kgs. of P_2O_5 per hectare. In Andhra and Orissa States of India, no data has been given on the responses of promising lines to different levels of fertility. Breeding work is still in progress in Malaya, Burma, India, Philippines, Thailand, Pakistan, Vietnam and N. Australia and it is expected that the results from these countries on the evaluation of selections to different levels of fertilizer application would be available in due course.

TABLE 1

Country-wise data on number of cross combination, F_2 population and selection percentage in F_2S

Countries	No. of local varieties		Total number of cross combination	Average F_2 population per combination	Method of breeding		No. of localities for selection	Selection percentage in F_2
	Initial Program	Extended Program			Pedigree	Bulk		
Burma	4	10	66	250	x	x	2	1.1
India–FAO–ICAR scheme	3	64	320	500 (CRRI, Cuttack)	x		1	1.0
Indonesia	2	8	38	5200	x		1	1.6
Malaya	4	10	57	1150	x	x	3	5.4
E. Pakistan	4	6	35	160	x		1	4.6
Philippines	5	10	68	114	x	x	2	–
Thailand	4	10	66	2333	x		1	80.0
Vietnam	4	6	53	–	x		1	–
Ceylon	2	–	19	Work discontinued as the material was not found suitable				
Egypt			20					
Australia			39	–	–	–	–	–

TABLE 2

Yield data from F_7 cultures at two levels of soil fertility (1957-58)

Central Rice Research Institute, Cuttack, India

Culture parentage	Yield (k.g. per ha)				% increase in hybrid over indica		% increase in hybrid HF over	% increase in indica HF over
	hybrid cultures		Indica parent					
	NF	HF	NF	HF	NF	HF	NF	NF
T. 1145 × Taihoku	3354 x	3303	2736	2998	22.6	10.2	–1.6	9.6
GEB 24 × Aikoku	3341 x	3340	2496	3360	33.9	–0.6	–0.04	34.6
BAM 9 × Norin 18	3329 x	3594 xx	2820	3671	18.0	–2.1	7.97	30.1
T. 1145 × Aikoku	3270 xx	2933	2736	2998	19.5	–2.2	–10.4	9.6
GEB 24 × Asahi	3024 xx	2439	2496	3360	21.1	–27.4	–13.3	34.6
T. 1145 × Asahi	3111 xx	2736	2736	2998	13.7	–8.8	–12.1	9.6
BAM 6 × Taihoku	2934 xx	2672	3157	2643	–7.1	1.2	–11.0	–16.2
T. 1145 × Norin 36	2872	2960	2736	2998	4.9	–1.3	3.1	9.6
BAM 6 × Norin 36	2864	2756	3157	2643	–9.3	4.3	–11.6	–16.2
GEB 24 × Taichu 65	2744 xx	2192	2496	3360	9.9	–34.8	–20.2	34.6
T. 1145 × Norin 18	1867	2400 xx	2736	2998	–31.7	–19.9	28.5	9.6
T. 90 × Norin 36	2495	2648 xx	3189	2020	–22	31.1	6.1	–36.6

C.D to compare variety means at two levels of fertility = 214.5 kg.

x significantly superior to indica parent

xx ,, ,, over the opposite fertility level

TABLE 3

Performance of F_2 generation of the cross Zuiho × T. 141 and of the indica parent at three levels of soil fertility, 1958-59 at Central Rice Research Institute, Cuttack, India.

Levels of soil fertility	F_2			T. 141		
	N.F. field	H.F. field	V.H.F. (Pots)	N.F.	H.F.	V.H.F. (Pots)
F_2 population	198	208	74	20	20	5
Plant height (cm)						
Range	72-150	84-156	96-170	135-150	135-150	137-147
Mean	117.3	120.8	133.5	137.3	139.1	138.2
Ear bearing tillers plant						
Range	7-33	7-35	12-43	23-32	18-38	18-25
Mean	13.7	14.3	24.8	28.1	29.2	20.8
Spikelet Sterility						
Range	9.3-96.6	5.3-70.2	5.1-87	4.3-16.9	3.8-13.7	1.8-39.5
Mean	37.5	37.7	40.25	10.3	8.06	27.32
Single Plant Yield (gm)						
Range	1-43	1-52	8-78	48-83	47-87	40-52
Mean	14.35	16.74	36.5	70.5	71.6	43.5
Yield Class (gm) with maximum frequency in No. of plants	8-16 (Freq.15)	16-24 (Freq.18)	41-48 (Freq.26)			
No. of plants yielding above 40 grams.	4	6	39			

SUMMARY REPORT OF 1959 MEETINGS OF THE TWO WORKING PARTIES OF THE INTERNATIONAL RICE COMMISSION

At the sixth session of the I.R.C. held at Tokyo in 1958, it was decided the Working Party on Rice Production and Protection and the Working Party on Rice Soils, Water and Fertilizer Practices be established to continue the work and scope of the previous Working Parties on Rice Breeding and Fertilizers. The first meeting of both the Working Parties (8th in the series for the former and 7th in the series for the latter) was held concurrently from 14-19 December 1959 at the University Campus at Peradeniya, Ceylon through the kind invitation of the Government of Ceylon. They were attended by 66 participants representing 17 Governments and two special organizations. During the sessions, study and excursion trips were arranged to visit the Laboratories of the Agricultural Institute, Experimental Stations and the famous botanical garden at Peradeniya.

The following is a summary of the recommendations and decisions of the meetings of the two Working Parties.

Working Party on Rice Production and Protection recommended that:-

1) in all countries where the indica-japonica project is in progress, further selections in the hybrid material should be done on a high soil fertility level, and that in the new hybrids to be produced between the most suitable indica and japonica varieties, all the hybrid generations from F_2 onwards be grown under high fertility soil conditions and selection made in accordance to the decisions reached at the meeting.

2) the list of genetic symbols recommended by the I.R.C. be published in the I.R.C. News Letter for adoption by the Rice Geneticists in their future publications.

3) in the future new gene symbols in conformity with the rules adopted by the Tenth International Genetics Congress be set up by the workers as the need arises.

4) the Cooperative Variety Trials in the present form be discontinued and replaced by a project aiming at testing promising varieties which have shown wide adaptability in the country of origin for their suitability in other parts of the region and a detailed plan for this project formulated.

5) extensive regional testing of varieties should be conducted as a basis for the evaluation of already existing and of new varieties: the best varieties with greater adaptation to be multiplied and distributed to farmers as soon as possible: in the breeding programs of the countries, greater emphasis be placed on selection for varieties with widest possible adaptability.

6) fundamental studies on photoperiodism and thermo-sensitivity of rice varieties should receive greater attention in order to provide the breeders with basic information relating to the adaptability of varieties.

7) in all countries steps should be taken to strengthen the work on rice seed improvement and special emphasis be given to extensive variety tests, reduction of the number of varieties and production and distribution of seed of improved varieties.

8) Member Governments should make a careful survey of all pests and diseases damaging paddy in the field and provide FAO with lists of these pests and diseases indicating the degree of economic importance (major and minor) of each organism and notify FAO when any new species is found. FAO in turn should prepare and maintain a list of the species and their distribution on the basis of these reports and other data and circulate the same to the member countries for their information, comments and suggestions.

9) Member Governments should take immediate steps to secure information on the overall losses caused by insect pests and whenever possible, the losses caused by individual paddy pests.

10) Member Governments keep FAO regularly informed of effective new or improved pesticide techniques for control of various paddy pests and that FAO circulate this information to Member Countries through the I.R.C. News Letter, the FAO Plant Protection Bulletin or by direct correspondence as may be most appropriate.

11) Member Governments should consider enacting regulations to control the importation, manufacture, formulation, packaging, labelling, distribution of chemicals within their territories.

12) Member Governments consider ways and means of developing effective methods for control of pesticide residues to protect consumers of treated crops from possible hazardous residues.

13) FAO to consider the possibility of organizing a study group to review the program of studies on the important insect pests such as stem borers, gall flies, etc. in order to develop a coordinated program for the reduction of losses caused by them.

14) Member Countries be requested, in so far as available personnel will permit, to make detailed surveys and collect information and specimens of various natural enemies including pathogens of rice stem borers and other insect pests of paddy and have them identified.

15) Member Countries be requested to review the lists of parasites and predators compiled by FAO and to send suggestions, corrections, and additions including lists of pathogens to Harry G. Walker, FAO, Rome, Italy, for use in the preparation of a revised edition and in the development of a complete file on the available information on this subject.

16) FAO assist Member Countries, when requested, in making arrangements for the exchange of parasites, predators and pathogens under the supervision of the Commonwealth Institute of Biological Control or other responsible Organization working in this field: that in view of the great importance of these exchanges to the world food supply, consideration be given to the enactment of well co-ordinated regulations for the safe and rapid transportation of these specimens at reduced rates by the airlines: where necessary, all governments are requested to amend their plant quarantine as well as import or export regulations in order

to expedite the transfer of these beneficial specimens as rapidly as possible and issue necessary instructions to their respective Customs and Commerce authorities in order to avoid delays in shipment and the loss of valuable living specimens.

17) FAO investigate the possibilities of having the valuable Japanese contributions to the knowledge of insects, diseases, weeds and other pests of paddy translated into English and French either in full or in abstract and circulated to members of the International Rice Commission and its Working Party on Rice Production and Protection.

18) uniform blast nurseries be established in as many of the participating countries as possible and the detailed plans and instructions for these nurseries should be worked out by a small committee consisting of Dr. L.H. Fernando (Ceylon) Chairman, Dr. H. Okamoto (Japan) and Mr. S. Y. Padmanabhan (India), and that FAO should collect seed of varieties resistant to blast in the country of origin to be included in these nurseries.

19) all countries send FAO any new information concerning the resistance to blast and other diseases of various varieties, whenever such information is obtained, and that this information be published as an appendix to the genetic stocks catalogue.

20) further work on blast race identification be carried out in all countries wherever facilities for such work exist and that all results in this field be reported at the next meeting of the Working Party.

21) work on breeding for resistance to other diseases and pests be continued and strengthened in those countries where resistant varieties are needed, and that results from that work be reported to the next meeting.

22) Member Countries should thoroughly study all phases of the complex problem of weed control and report on the results obtained at the next meeting of the Working Party.

The Working Party on Rice Soils, Water and Fertilizer Practices recommended that :-

1) since an urgent need is felt for more basic knowledge on the soil conditions of rice producing regions of the world, soil surveys in these regions be strongly promoted especially to obtain an inventory of the soils on which rice can be grown.

2) the classification of soils on which rice is grown be developed where possible in accordance with an internationally accepted system of soil classification.

3) precise descriptions be prepared of the main rice producing soils in terms of a generally accepted morphological terminology, which however needs improvement for certain soils under sustained irrigation. It was further recommended that this kind of information be widely circulated amongst the member countries.

4) although the fertilizer trials at the experimental stations should undoubtedly be the basis for developing knowledge on fertilizer use because such trials can cope with many factors and can be adequately supervised, but that the results

of such trials cannot be directly used beyond the experimental station area, therefore Member Governments should undertake numerous simple fertilizer tests on cultivators fields selected at random within any particular soil unit to enable statistical interpretation of the results. Such tests would provide the information needed for the efficient use of fertilizers by cultivators. The Working Party further recommended that these investigations be paralleled by economic studies to determine the net financial returns from the use of the most efficient combinations of fertilizer materials and that the staff necessary to supervise the simple field tests be recruited and trained.

5) the attention of Member Countries be drawn to the value of large scale soil testing for establishing the fertility levels. It was further recommended that the chemical tests be correlated with field fertilizer responses. In this connection, the Working Party noted with satisfaction the progress achieved in India with the establishment and operation of 24 soil testing laboratories.

6) since different methods for determination of available phosphorus and potassium have shown different degrees of correlation with crop responses to fertilizer treatment, Member Countries should evaluate on cooperative basis these methods to select the most suitable ones. Exchange of information amongst the participating countries in this project may be of considerable assistance.

7) in view of likely considerable increase of fertilizer use in Asia and Far East region, FAO be requested to advise Member Governments on the adoption of uniform fertilizer control legislation including fertilizer specifications, standardization, terminology, methods of analysis; sales regulations, etc.

8) since a number of papers reporting fertilizer responses did not describe the climatic, soil and water conditions under which the experiments were conducted, more attention be given to these aspects in the future, to facilitate interpretation of the results obtained.

9) in presenting the result of field experiments at international meetings a uniform system of measurement be used such as a metric system and explanation be given whether the figures refer to milled or unmilled rice.

10) as there still appears to be disagreement on the best method and time of application of fertilizers especially with reference to nitrogen fertilizers this subject should receive special attention by Member Countries.

11) those governments who have not as yet appointed Liaison Officers for the Working Party as recommended by the sixth session of the International Rice Commission, be requested to do so at an early date.

12) since no accurate statistics are available in many of the Member Countries on amounts and rates of fertilizer used on different crops, this information be collected through properly conducted surveys to help in future country planning for increased crop production and fertilizer manufacture and imports.

13) in view of the urgent need for increasing yields per hectare, which can only be achieved through sustained efforts on the part of Member Governments, the list of projects prepared by the Working

Party be circulated by FAO to Member Governments for their consideration and action. In circulating this information FAO present to the Governments the views expressed in the Working Party on the importance and priorities of these projects. The Working Party further recommended that those countries which are likely to implement such projects but unable to do so with their own resources should seek the help of FAO under the Expanded Technical Assistance Program or the UN Special Fund.

14) in view of the reconstitution of the Working Party on Rice Soils, Water and Fertilizer Practices which has to deal with many diverse and specialized subjects, Member Governments, to the extent possible, ensure that the composition of their delegations would be such as to enable specialists in the different disciplines to present and discuss the information which is of importance and mutual benefit to all Member Countries.

15) the Regional Soil Fertility Specialist for Asia and the Far East continues to contact Member Governments concerning the implementation of the recommendations of the Working Party.

16) in view of the importance of maintaining the soil in good physical condition for increasing rice yields and as not enough data are yet available on the physical condition of soils in relation to irrigation, drainage and tillage practices, Member Governments undertake coordinated projects to investigate the problems concerning time, method and depth of tillage, intercultivation of crops, fertilizer use, irrigation and drainage control in relation to the physical condition of the soil and the effect of these factors on the productive capacity of the soil. The Working Party further considered that these problems could best be resolved by the concerted efforts of a number of specialists working together, such as soil physicist, soil chemist, irrigation agronomist and an agricultural engineer (tillage).

The joint sessions of the Working Parties on Rice Production and Protection and on Rice Soils, Water and Fertilizer Practices recommended that:-

1) member Countries should strengthen their investigations on physiological diseases of rice on a cooperative basis and that Dr. J. Takahashi of Japan be requested to act as coordinator.

2) in view of the great possibilities for increasing rice production through the use of fertilizers, the investigations on variety fertilizer interaction be continued and that Dr. M.F. Chandraratne of Ceylon be requested to act as coordinator.

3) in conducting the variety x fertilizer interaction trials sufficiently large number of fertility levels be included to make calculations of response curves practicable and that to the extent possible all other limiting factors be removed by applying sufficient amounts of the plant nutrients not being tested and by using the best cultural practices.

4) in the future, in plant breeding strong emphasis be given to breeding for high fertilizer response, for resistance to lodging and diseases and that testing for yield should be done at least at two levels of fertility (normal and high).

5) countries which maintain the world genetic stock of indicas be requested to grow these stocks under high level of fertility and that records be taken of the straw : grain ratio as well as the panicle number and weight.

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